

IMAGE PROCESSING METHOD, IMAGE PROCESSING
APPARATUS, AND STORAGE MEDIUM

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to an image processing method which is applied to a fax machine, a copying machine and the like, an image processing apparatus which adopts the above image processing method, and a storage medium which stores a control program to control the above image processing apparatus.

10 Related Background Art

Generally, an image which is managed by a fax machine, a copying machine and the like has determined size and shape. This shape is a rectangle extending longitudinally or laterally.

In the currently spreading small fax machines, there are a lot of types that the image is processed in the longitudinal direction (i.e., a portrait orientation). On the other hand, in the currently spreading heavy fax machines, there are a lot of types that the image is processed in the lateral direction (i.e., a landscape orientation).

25 Thus, in the heavy fax machines having a fax transmission function, there is a type which performs, even if the original is read in the lateral direction,

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an image rotation process of 90° or 270° to turn the read image toward the longitudinal direction and then fax transmit the turned image.

Similarly, there is a type which performs the
5 image rotation process of 90° or 270°, when the image data is fax received, to turn the output image toward the direction same as that of the image output when the copying machine is normally used.

Further, there is an image reading apparatus which
10 performs the image rotation process of 90°, 180° or 270° to transmit the image data to a connected apparatus such as an image server or the like to which the direction of the image to be transmitted has been defined, or performs the image rotation process of 90°,
15 180° or 270° to correspond to a user's demand to orient the output images toward a certain direction.

Further, e.g., in a case where the image is printed on a transparent sheet, there is an apparatus which has an image right-and-left or up-and-down reversal function to be able to perform an image reversal process to print a mirror image. In the mirror image, the image has been right-and-left or up-and-down reversed and printed such that, when the printed image is viewed from the back face of this
25 transparent sheet, it becomes the faithful image.

In order to satisfy the demand of such the image rotation process of 90°, 180° or 270° or the image

right-and-left or up-and-down reversal process as above, there is an image processing apparatus which achieves such an image rotation/reversal process. In this image processing apparatus, a dedicated memory array or shift register on which data writing and reading can be performed in both the longitudinal and lateral directions is provided, and the direction of the data writing is made different from the direction of the data reading to achieve the image 5 rotation/reversal process.

However, if the dedicated memory array or shift register is used, dedicated circuits for the image rotation and the image reversal are necessary, whereby a memory circuit is complicated as a whole. Thus, a 10 circuit scale becomes large, and thus the cost for achievement rises. Further, the limit of an operation clock frequency capable of operating at high speed is lowered, and the entire circuit has to be designed as exclusive use, whereby expansion and diversion of the 15 circuit are difficult.

Further, the image rotation/reversal process is performed according to a procedure that pixel data representing the image is once stored in an internal memory and then read therefrom. Further, there has 20 been known a method that the pixel data representing the image is not processed at one time, but the entire image is first divided into blocks each having the 25

small number of composite pixels, and the image rotation/reversal process is performed for each of the small image data blocks.

Then, to achieve the rotation/reversal process for
5 the entire image by rearranging the positions of all
the image data blocks to which the rotation/reversal
process has been performed pro re nata, a rearrangement
process is performed for each block by means of an
external circuit or software independent of an image
10 rotation and reversal processing apparatus.

The reason of adopting such a structure, i.e., the
reason of not performing the rotation/reversal process
for the entire image at one time, is that, since the
image managed in the fax machine and the copying
15 machine is obtained by reading an original of A4 or
letter size at resolution of 200dpi (dots per inch) or
600dpi and therefore the total number of pixels
constituting the original image is remarkably large, an
unrealistic large memory capacity is necessary when the
20 entire image is stored in the memory array, the shift
register or a general-purpose memory at one time to
perform the image rotation/reversal process.

However, in the case where the rearrangement
process is performed for each block by using the
25 external circuit independently of the image rotation
and reversal processing apparatus, or in the case where
the rearrangement process is performed for each block

by using the software, problems occur in processing speed and a parallel operation because of the following reason. Namely, when the rearrangement process is performed for each block, it is necessary to repeatedly

5 perform the reading and the writing for each block on a page memory capable of storing the entire image plural times corresponding to the number of all the blocks.

Thus, by repeatedly performing such the processes for all the blocks, it takes excessive processing time

10 corresponding to the time necessary for reading the entire image and the time necessary for writing the entire image in addition to the time necessary for the image rotation/reversal process.

Further, the unit of the above image

15 rotation/reversal process is the entire image. Even if there is a request of the image rotation/reversal process for plural images, it is impossible to simultaneously perform these processes in parallel, and it is also impossible to interrupt the image process being performed. Thus, in this case, since it only waits until the image process which is being performed ends, a priority process or the like which preferentially processes the image to which the process was requested later can not be performed.

20
25 Further, since one image rotation and reversal processing apparatus is allocated to one image without fail, even if the number of the image rotation and

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reversal processing apparatuses is increased, these image rotation and reversal processing apparatuses can not process the one image in parallel, whereby the process can not be completed at high speed.

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SUMMARY OF THE INVENTION

The present invention is to solve the above problems in the conventional art, and a first object of the present invention is to provide image processing method and apparatus which can minimize circuit scale to perform an image rotation/reversal process, increases an operation clock frequency of the entire apparatus to easily enable a high-speed operation, and is excellent in expansion and diversion of the circuit.

10 15 A second object of the present invention is to provide a storage medium which stores a control program to control the image processing apparatus achieving the first object of the present invention.

20 25 A third object of the present invention is to provide image processing method and apparatus which can shorten a time necessary to perform an image rotation/reversal process, equally achieve a parallel process, and have expansion for high-speed image rotation/reversal process.

25 A fourth object of the present invention is to provide a storage medium which stores a control program to control the image processing apparatus achieving the

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third object of the present invention.

In order to achieve the above first object, an image processing method according to the present invention comprises:

- 5 a numerical signal generation step of sequentially generating and outputting regular binary numerical signals in synchronism with a clock signal;
- 10 a bit exchange step of generating and outputting, from the output signal in the numerical signal generation step being managed as an input signal, a signal that order of bits in the input signal has been exchanged or a signal that the bits in the input signal have been reversed; and
- 15 a control step of controlling the bit order exchange operation or the bit reversal operation in the bit exchange step,
- 20 wherein image data divided into pixel data and one-dimensionally arranged and stored in a memory is read and output in synchronism with the sequential operation in the numerical signal generation step, and the output signal generated in the bit exchange step is read and output as an address signal, so that a rotation/reversal process to a former image is performed.
- 25 Further, in order to achieve the above first object, an image processing apparatus according to the present invention comprises:

a numerical signal generation means for sequentially generating and outputting regular binary numerical signals in synchronism with a clock signal;

- 5 a bit exchange means for generating and outputting, from the output signal of the numerical signal generation means being managed as an input signal, a signal that order of bits in the input signal has been exchanged or a signal that the bits in the input signal have been reversed;
- 10 a control means for controlling the bit order exchange operation or the bit reversal operation of the bit exchange means; and
- 15 a storage means for storing image data, wherein the image data divided into pixel data and one-dimensionally arranged and stored in the storage means is read and output in synchronism with the sequential operation of the numerical signal generation means, and the output signal generated by the bit exchange means is read and output as an address signal,
- 20 so that a rotation/reversal process to a former image is performed.

Further, in order to achieve the above first object, an image processing method according to the present invention comprises:

- 25 a numerical signal generation step of sequentially generating and outputting regular binary numerical signals in synchronism with a clock signal;

a bit exchange step of generating and outputting,
from the output signal in the numerical signal
generation step being managed as an input signal, a
signal that order of bits in the input signal has been
5 exchanged or a signal that the bits in the input signal
have been reversed; and

a control step of controlling the bit order
exchange operation or the bit reversal operation in the
bit exchange step,

10 wherein image data is written in a memory in
synchronism with the sequential operation in the
numerical signal generation step and by using the
output signal generated in the bit exchange step as an
address signal, and the image data written in the
15 memory is read according to addresses of predetermined
order, so that a rotation/reversal process to a former
image is performed.

Further, in order to achieve the above first
object, an image processing apparatus according to the
20 present invention comprises:

a numerical signal generation means for
sequentially generating and outputting regular binary
numerical signals in synchronism with a clock signal;

25 a bit exchange means for generating and
outputting, from the output signal of the numerical
signal generation means being managed as an input
signal, a signal that order of bits in the input signal

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has been exchanged or a signal that the bits in the input signal have been reversed;

a control means for controlling the bit order exchange operation or the bit reversal operation of the bit exchange means; and

5 a storage means for storing image data,

wherein the image data is written in the storage means in synchronism with the sequential operation of the numerical signal generation means and by using the output signal generated by the bit exchange means as an address signal, and the image data written in the storage means is read according to addresses of predetermined order, so that a rotation/reversal process to a former image is performed.

10 Further, in order to achieve the above second object, in a storage medium according to the present invention which stores a control program to control an image processing apparatus, the program comprises:

15 a numerical signal generation module of sequentially generating and outputting regular binary numerical signals in synchronism with a clock signal;

20 a bit exchange module of generating and outputting, from the output signal in the numerical signal generation module being managed as an input signal, a signal that order of bits in the input signal has been exchanged or a signal that the bits in the input signal have been reversed; and

a control module of controlling the bit order exchange operation or the bit reversal operation in the bit exchange module,

wherein image data divided into pixel data and
5 one-dimensionally arranged and stored in a memory is
read and output in synchronism with the sequential
operation in the numerical signal generation module,
and the output signal generated in the bit exchange
module is read and output as an address signal, so that
10 a rotation/reversal process to a former image is
performed.

Further, in order to achieve the above second
object, in a storage medium according to the present
invention which stores a control program to control an
15 image processing apparatus, the program comprises:

a numerical signal generation module of
sequentially generating and outputting regular binary
numerical signals in synchronism with a clock signal;
a bit exchange module of generating and
20 outputting, from the output signal in the numerical
signal generation module being managed as an input
signal, a signal that order of bits in the input signal
has been exchanged or a signal that the bits in the
input signal have been reversed; and
25 a control module of controlling the bit order
exchange operation or the bit reversal operation in the
bit exchange module,

wherein image data is written in a memory in synchronism with the sequential operation in the numerical signal generation module and by using the output signal generated in the bit exchange module as 5 an address signal, and the image data written in the memory is read according to addresses of predetermined order, so that a rotation/reversal process to a former image is performed.

Further, in order to achieve the above third 10 object, an image processing method according to the present invention comprising:

an input step of inputting a block image and positional information of the block image; 15 an image rotation/reversal processing step of rotating or reversing the input block image by a block, and outputting the rotated or reversed block image; and a conversion step of converting the positional 20 information of the input block image into the positional information of the image after the rotation or the reversal,

wherein the conversion in the conversion step is a process corresponding to the content of the image rotation or the image reversal in the image rotation/reversal processing step, and in the 25 conversion, the positional information for the entire image before the rotation or the reversal where the block image stands is converted into the positional

information for the entire image after the image rotation or the image reversal in the image rotation/reversal processing step, and the converted positional information is added to the rotated or
5 reversed block image and output.

Further, in order to achieve the above third object, an image processing apparatus according to the present invention comprising:

- an input means for inputting a block image and
10 positional information of the block image;
 - an image rotation/reversal processing means for rotating or reversing the input block image by a block, and outputting the rotated or reversed block image; and
 - a conversion means for converting the positional
15 information of the input block image into the positional information of the image after the rotation or the reversal,
- wherein the conversion by the conversion means is a process corresponding to the content of the image
20 rotation or the image reversal by the image rotation/reversal processing means, and in the conversion, the positional information for the entire image before the rotation or the reversal where the block image stands is converted into the positional
25 information for the entire image after the image rotation or the image reversal by the image rotation/reversal processing means, and the converted

positional information is added to the rotated or reversed block image and output.

Further, in order to achieve the above fourth object, in a storage medium according to the present invention which stores a control program to control an image processing apparatus, the control program comprises:

- an input module of inputting a block image and positional information of the block image;
- 10 an image rotation/reversal processing module of rotating or reversing the input block image by a block, and outputting the rotated or reversed block image; and
 a conversion module of converting the positional information of the input block image into the
15 positional information of the image after the rotation or the reversal,
 wherein the conversion in the conversion module is a process corresponding to the content of the image rotation or the image reversal in the image
20 rotation/reversal processing module, and in the conversion, the positional information for the entire image before the rotation or the reversal where the block image stands is converted into the positional information for the entire image after the image
25 rotation or the image reversal in the image rotation/reversal processing module, and the converted positional information is added to the rotated or

reversed block image and output.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

15 Fig. 1 is a block diagram showing a system structure of an image processing apparatus according to the embodiment of the present invention;

20 Fig. 2 is a vertical sectional view showing structures of a reader unit and a printer unit in the image processing apparatus according to the embodiment of the present invention;

25 Fig. 3 is a block diagram showing an internal structure of the reader unit in the image processing apparatus according to the embodiment of the present invention;

. Fig. 4 is a block diagram showing an internal structure of a core unit in the image processing

apparatus according to the embodiment of the present invention;

Fig. 5 is a block diagram showing an internal structure of a data processing unit in the image processing apparatus according to the embodiment of the present invention;

Fig. 6 is a block diagram showing an internal structure of an image rotation/reversal processing unit in the image processing apparatus according to the embodiment of the present invention;

Fig. 7 is a diagram showing a case where image data is divided into pixel data, in the image processing apparatus according to the embodiment of the present invention;

Fig. 8 is a diagram showing a case where the image data is rotated counterclockwise by 90°, in the image processing apparatus according to the embodiment of the present invention;

Fig. 9 is a diagram showing a case where the image data is rotated counterclockwise by 180°, in the image processing apparatus according to the embodiment of the present invention;

Fig. 10 is a diagram showing a case where the image data is rotated counterclockwise by 270°, in the image processing apparatus according to the embodiment of the present invention;

Fig. 11 is a diagram showing a case where the

image data is right-and-left reversed, in the image processing apparatus according to the embodiment of the present invention;

Fig. 12 is a diagram showing a case where the
5 image data is right-and-left reversed and then rotated
counterclockwise by 90° , in the image processing
apparatus according to the embodiment of the present
invention;

Fig. 13 is a diagram showing a case where the
10 image data is right-and-left reversed and then rotated
counterclockwise by 180° , in the image processing
apparatus according to the embodiment of the present
invention;

Fig. 14 is a diagram showing a case where the
15 image data is right-and-left reversed and then rotated
counterclockwise by 270° , in the image processing
apparatus according to the embodiment of the present
invention;

Fig. 15 is a list of bit exchange contents for
20 types of image rotation/reversal process in the image
processing apparatus according to the embodiment of the
present invention;

Fig. 16 is a bit exchange table for achieving
address control to rotate the image data
25 counter-clockwise by 90° , in the image processing
apparatus according to the embodiment of the present
invention;

Fig. 17 is a diagram showing a bit exchanger in the image processing apparatus according to the embodiment of the present invention;

5 Fig. 18 is a block diagram showing an internal structure of an image rotation/reversal processing unit in the image processing apparatus according to the second embodiment of the present invention;

10 Fig. 19 is a diagram showing a case where an image is divided and managed as plural images in the image processing apparatus according to the second embodiment of the present invention;

15 Figs. 20A, 20B, 20C, 20D and 20E is signal timing charts in a case where block data is transferred through an image bus in the image processing apparatus according to the second embodiment of the present invention;

20 Fig. 21 is a block position information conversion method list for types of image rotation/reversal process in the image processing apparatus according to the second embodiment of the present invention; and

Fig. 22 is a diagram showing a case where the images divided into 10 blocks in a horizontal direction and eight blocks in a vertical direction shown in Fig. 19 are rotated counterclockwise by 90°.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention

will now be described in detail in accordance with the accompanying drawings.

(First Embodiment)

Fig. 1 is a block diagram showing a system
5 structure of an image processing apparatus according to
the present embodiment. In Fig. 1, numeral 1 denotes a
reader unit which reads an image on an original and
then outputs image data corresponding to the read
original image to a printer unit 2 and an image
10 input/output control unit 3. Numeral 2 denotes the
printer unit 2 which forms on a recording sheet an
image corresponding to the image data input from the
reader unit 1 and the image input/output control unit
3. Numeral 3 denotes the image input/output control
15 unit which is connected to the reader unit 1 is
composed of a fax unit 4, a file unit 5, a computer I/F
(interface) unit 6, a formatter unit 7, an image memory
unit 8, a core unit 9 and the like.

The fax unit 4 expands compressed image data
20 received through a telephone line 10, and transfers the
expanded image data to the core unit 9. Further, the
fax unit 4 compresses image data transferred from the
core unit 9, and transmits the compressed image data
through the telephone line 10. An HD (hard disk) 11 is
25 connected to the fax unit 4, whereby the compressed
image data received can be temporarily stored in the HD
11.

An MO (magnetooptical) disk drive unit 12 is connected to the file unit 5. Thus, the file unit 5 compresses image data transferred from the core unit 9, and stores the compressed image data in an MO disk set
5 in the MO disk drive unit 12, together with a keyword used to retrieve such the compressed image data. The file unit 5 retrieves the compressed image data stored in the MO disk on the basis of the keyword transferred through the core unit 9, reads the retrieved image
10 data, expands the read image data, and then transfers the expanded image data to the core unit 9.

The computer I/F unit 6 interfaces a PC/WS (personal computer or working station) 13 with the core
15 unit 9.

The formatter unit 7 inputs code data representing an image transferred from the PC/WS 13, and expands the input code data to obtain the image data capable of being recorded by the printer unit 2.

The image memory unit 8 temporarily stores the
20 data transferred from the PC/WS 13.

The core unit 9 controls the data flow among the reader unit 1, the fax unit 4, the file unit 5, the computer I/F unit 6, the formatter unit 7 and the image memory unit 8.

25 Fig. 2 is a vertical sectional view showing structures of the reader unit 1 and the printer unit 2. In Fig. 2, an original feeder 101 of the reader unit 1

feeds one by one the original from its last page in due order to a platen glass 102. After an original reading operation ended, the original feeder 101 discharges the original from the platen glass 102.

5 When the original is transported onto the platen glass 102, a lamp 103 is lit, and movement of a scanner unit 104 is started, whereby the original is exposed and scanned. At this time, reflection light from the original is guided into a CCD (charge-coupled device) 109 by
10 means of mirrors 105, 106 and 107 and a lens 108. An image of the original scanned as above is read by the CCD 109. Image data output from the CCD 109 is subjected to a predetermined process, and then
15 transferred to the printer unit 2 and the core unit 9 of the image input/output control unit 3.

A laser driver 201 of the printer unit 2 drives a laser beam generator 201a to generate a laser beam in response to the image data output from the reader unit
20 1. The generated laser beam is irradiated on a photosensitive drum 202, whereby a latent image corresponding to the irradiated laser beam is formed on the photosensitive drum 202. Then, a development agent is adhered by a development unit 203 to the part
25 corresponding to the latent image on the photosensitive drum 202. At timing synchronous with a start of the laser beam irradiation, a recording sheet is fed from

either an upper sheet feed cassette 204 or a lower sheet feed cassette 205 to a transfer unit 206, and the development agent on the photosensitive drum 202 is transferred to the fed recording sheet. The recording
5 sheet to which the development agent has been transferred is then transported to a fixing unit 207, and thus the development agent is fixed to the recording sheet by heat and pressure of the fixing unit 207. The recording sheet passed the fixing unit 207 is
10 discharged by discharge rollers 208. Then, a sorter 211 holds the discharged sheets to respective bins 212 to sort the recording sheets.

When a sorting mode is not set, the sorter 211 holds all the discharged recording sheets to the
15 uppermost bin 212. Further, when a two-faced recording mode is set, the recording sheet is transported to the discharge rollers 208, and then the rotation direction of the roller 208 is reversed, whereby the transported sheet is guided to a sheet refeed path 210 by a flapper 209. Further, when a multirecording mode is set, the
20 recording sheet is not transported to the sheet discharge rollers 208 but guided to the sheet refeed path 210 by the flapper 209. The recording sheet guided to the sheet refeed path 210 is then transported
25 to the transfer unit 206 at the above timing.

Fig. 3 is a block diagram showing an internal structure of the reader unit 1. In Fig. 3, numeral 109

denotes a CCD, numeral 110 denotes an A/D and SH
(analog-to-digital conversion and shading correction)
unit, numeral 111 denotes an image processing unit,
numeral 112 denotes an I/F, numeral 113 denotes a CPU
5 (central processing unit), numeral 114 denotes an
operation unit, and numeral 115 denotes a memory.

In Fig. 3, the image data output from the CCD 109
is subjected to an A/D conversion process and a shading
correction process by the A/D and SH unit 110. The
10 image data processed by the A/D and SH unit 110 is
transferred to the printer unit 2 through the image
processing unit 111, and also transferred to the core
unit 9 of the image input/output control unit 3 through
the I/F 112.

15 The CPU 113 controls the image processing unit 111
and the I/F 112 according to setting contents set on
the operation unit 114. For example, when a copying
mode to perform a trimming process and then perform an
copying operation is set on the operation unit 114, the
20 CPU 113 causes the image processing unit 111 to perform
the trimming process and then transfer the processed
data to the printer unit 2. Further, when a fax
transmission mode is set on the operation unit 114, the
CPU 113 causes the I/F 112 to transfer the image data
25 and a control command according to the set mode to the
core unit 9.

A control program for the CPU 113 has been stored

in the memory 115, whereby the CPU 113 performs the control with reference to the control program in the memory 115. Further, the memory 115 is used as a working area of the CPU 113.

5 Fig. 4 is a block diagram showing an internal structure of the core unit 9. In Fig. 4, numeral 900 denotes an I/F, numeral 901 denotes a data processing unit, numeral 902 denotes an I/F, numeral 903 denotes a CPU, and numeral 904 denotes a memory.

10 In Fig. 4, the image data from the reader unit 1 is transferred to the data processing unit 901, and a control command from the reader unit 1 is transferred to the CPU 903. The data processing unit 901 performs various image processes such as an image rotation process, a magnification change process and the like. The image data transferred from the reader unit 1 to the data processing unit 901 is then transferred to the fax unit 4, the file unit 5 and the computer I/F unit 6 through the I/F 900, in response to the control command transferred from the reader unit 1. Further, code data representing an image input through the computer I/F unit 6 is once transferred to the data processing unit 901, and then transferred to the formatter unit 7 to be expanded into image data. The expanded image data is transferred to the data processing unit 901, and then transferred to the fax unit 4 and the printer unit 2.

Image data from the fax unit 4 is once transferred

to the data processing unit 901, and then transferred to the print unit 2, the file unit 5 and the computer I/F unit 6.

The CPU 903 performs such the control as described above in accordance with the control program stored in the memory 904 and the control command transferred from the reader unit 1. Further, the memory 904 is used as a working area of the CPU 903. Thus, a process in which the functions of original image reading, image printing, image transmission/reception, image storing, data input/output from/to the PC/WS 13 and the like are composited to others can be performed mainly in the core unit 9.

Fig. 5 is a block diagram showing an internal structure of the data processing unit 901. In Fig. 5, numeral 9010 denotes a magnification change processing unit, numeral 9011 denotes an image rotation/reversal processing unit, numeral 9012 denotes a memory, numeral 9013 denotes an image bus, numeral 9014 denotes an address bus, and numeral 9015 denotes a data bus.

In Fig. 5, the image data from the reader unit 1 is transferred to the data processing unit 901 through the I/F 902. Further, the image data from the fax unit 4, the file unit 5, the formatter unit 7 and the image memory unit 8 is transferred to the data processing unit 901 through the I/F 900.

The image bus 9013 is a shared transmission path.

The image data is transferred to the magnification change processing unit 9010 when the magnification change process is performed under the control of the CPU 903, while the image data is transferred to the 5 image rotation/reversal processing unit 9011 when an image rotation/reversal process is performed under the control of the CPU 903. Then, the magnification change process is performed by the magnification change processing unit 9010, and the image rotation/reversal 10 process is performed by the image rotation/reversal processing unit 9011. The memory 9012 is connected to the image rotation/reversal processing unit 9011, whereby the image data is temporarily stored in the memory 9012 while the image rotation/reversal process 15 is being performed.

Fig. 6 is a block diagram showing an internal structure of the image rotation/reversal processing unit 9011. In Fig. 6, numeral 90110 denotes a rotation/reversal mode memory, numeral 90111 denotes a bit exchanger, numeral 90112 denotes a counter, and numeral 90113 denotes an image bus I/F. 20

In Fig. 6, image data from the image bus 9013 is transferred to the data bus 9015 through the image bus I/F 90113. The counter 90112 outputs ascending-order 25 binary numbers, and the output of this counter 90112 is output to the address bus 9014 through the bit exchanger 90111 to control writing and reading

addresses of the memory 9012. It should be noted that the counter 90112 sequentially generates and outputs regular binary numerical signals in synchronism with a certain clock signal. The bit exchanger 90111 is the
5 bit arrangement changer which changes the order of input bit data and outputs the data in the changed order. The bit exchanger 90111 which has a function to rearrange the input bit data for each bit and a function to perform bit reversal of the value of each
10 bit data is controlled by the rotation/reversal mode memory 90110. The rotation/reversal mode memory 90110 consists of a register of which the contents can be rewritten and read by the CPU 903, and acts as the part to determine the operation of the image
15 rotation/reversal processing unit 9011.

Hereinafter, a procedure to perform the image rotation/reversal process in the data processing unit 901 will be explained.

When the image rotation/reversal process is
20 performed, the image data stored in the image memory unit 8 is transferred to the image rotation/reversal processing unit 9011 through the I/F 900 and the image bus 9013 under the control of the CPU 903. At this time, the image data is transferred and input to the
25 image rotation/reversal processing unit 9011 for each pixel in synchronism with a transfer clock of the image bus 9013. Then, the image rotation/reversal processing

unit 9011 stores the received image data in the memory 9012. In this case, a general-purpose memory controllable through the address bus 9014 and the data bus 9015 is used as the memory 9012.

5 After the image data of which the defined size had been previously set by the CPU 903 was received, the image rotation/reversal processing unit 9011 starts to read the image data from the memory 9012 for each pixel. Here, order of reading pixel data by
10 controlling the address bus 9014 to the memory 9012 has been changed from order of writing the pixel data. The image rotation/reversal process is achieved by such the control. For example, if the image data are sequentially read in the order opposite to that in case
15 of the data writing, the image which has been rotated by 180° can be obtained. On the other hand, if the image data are sequentially read in the order same as that in case of the data writing, the image which has been rotated by 0° (i.e., an unrotated and unreversed
20 image) can be obtained. The details of this operation will be described later.

The read image data is transferred to output destinations such as the fax unit 4, the file unit 5, the image memory unit 8 and the like through the image
25 bus 9013 and the I/F 900.

Fig. 7 is a diagram showing a case where all pixels of image data of 16-pixel square are added

respectively with unique numbers. In Fig. 7, it is assumed that each of small squares corresponds to each pixel constituting the image data of 16-pixel square, and the image data of one pixel is eight-bit data.

5 Hereinafter, a case where such a pixel block of 16-pixel square is rotated will be explained.

 Here, the rule of the order of the pixels in the case where the image transferred from the image bus 9013 is divided into the plural pixels and then the
10 divided pixel is transferred one by one is assumed as follows. In the pixels which are not yet transferred, the leftmost pixel in the uppermost pixel group is first transferred. Namely, the pixels are sequentially transferred in the numerical order shown in Fig. 7.
15 Therefore, the pixel data are sequentially input to the image rotation/reversal processing unit 9011 in the numerical order shown in Fig. 7, while the pixel data are sequentially output from the image rotation/reversal processing unit 9011 in the numerical
20 order shown in Fig. 7. Namely, in the image processing apparatus according to the embodiment of the present invention, since the image is transferred pixel by pixel in synchronism with a clock in the unit of pixel data, the image is managed as a one-dimensional pixel
25 data string along a time axis when the image is transferred onto the image bus. Further, when the image is stored in the unit of pixel in a memory having

a one-dimensional address space, this image is managed as a one-dimensional pixel data string along an address axis. Therefore, the image data shown in Fig. 7 is managed as the one-dimensional pixel data string,

5 whereby the pixels in this string are transferred one by one in synchronism with the clock in the order of "0", "1", "2", "3", "4", "5", ..., "254" and "255". Similarly, when the image data shown in Fig. 7 is stored in the memory, the pixels are sequentially

10 stored one by one in correspondence with the respective addresses in the order of "0", "1", "2", "3", "4", "5", ..., "254" and "255". It should be noted that such a technique of representing the two-dimensional image data as the one-dimensional pixel data string is

15 generalized, and this technology is convenient in a notation. Thus, hereinafter, the one-dimensional pixel data string in the data transfer operation will be conveniently shown by using such the drawing as in Fig. 7 numerically representing the two-dimensional image.

20 Similarly, the one-dimensional pixel data string in the data storage operation will be conveniently shown by using such the drawing as in Fig. 7 numerically representing the two-dimensional image. As described above, the order of one-dimensional pixel string at

25 this time is assumed to be the numerical order shown in Fig. 7, i.e., the order of "0", "1", "2", "3", "4", "5", ..., "254" and "255". In any event, the following

explanations will be performed on the premise that also the one-dimensional image data string is shown with the drawing numerically representing the two-dimensional image.

5 The image rotation/reversal processing unit 9011 has two operation steps, i.e., an image data input step and an image data output step. In the image data input step, as described above, the image data for each pixel is input to the image rotation/reversal processing unit
10 9011 through the image bus 9013. Further, in the image data output step, as described above, the image data is output from the image rotation/reversal processing unit 9011 through the image bus 9013.

15 These two operation steps will be explained hereinafter with reference to Fig. 6 being the block diagram showing the structure of the image rotation/reversal processing unit 9011.

In the image data input step, the image rotation/reversal processing unit 9011 writes the pixel data sequentially input in the order shown in Fig. 7 in the memory 9012. At this time, the address of the pixel number shown in Fig. 7 is used as the writing address such that the writing address becomes unique with respect to each pixel data. Concretely, a bit exchange in the bit exchanger 90111 is set to be through, and the output completely same as the output of the counter 90112 is transferred to the address bus
20
25

9014, whereby the pixel data is written in the memory
9012. After the transfer of all the pixel data ended
and the writing of all the pixel data in the memory
9012 ended, the operation step of the image
5 rotation/reversal processing unit 9011 is changed to
the image data output step.

In the image data output step, the image
rotation/reversal processing unit 9011 sequentially
reads the image data stored in the memory 9012, and
10 transfers the read data for each pixel through the
image bus 9013. In this case, the reading order of the
data from the memory 9012 and the transferring order of
the data to the image bus 9013 are controlled as
follows according to a kind of rotation process
15 performed to the image data and whether or not the
reversal process is performed.

When the image rotation process of 90°
counterclockwise is performed, the data is read in the
order indicated by a pixel block of 16-pixel square
20 shown in Fig. 8, i.e., the order of "15", "31", "47",
"63", "79", "95", "111", "127", "143", "159", "175",
"191", "207", "223", "239", "255", "14", "30", "46",
..., "208", "224" and "240".

Similarly, when the image rotation process of 180°
25 counterclockwise is performed, the data is read in the
order indicated by a pixel block of 16-pixel square
shown in Fig. 9. When the image rotation process of

270° counterclockwise is performed, the data is read in the order indicated by a pixel block of 16-pixel square shown in Fig. 10. Further, when the image reversal process is performed, the data is read in the order
5 indicated by a pixel block of 16-pixel square shown in Fig. 11. Further, when the image rotation process of 90° counterclockwise is performed after the image reversal process was performed, the data is read in the order indicated by a pixel block of 16-pixel square
10 shown in Fig. 12. Similarly, when the image rotation process of 180° counterclockwise is performed after the image reversal process was performed, the data is read in the order indicated by a pixel block of 16-pixel square shown in Fig. 13. When the image rotation
15 process of 270° counterclockwise is performed after the image reversal process was performed, the data is read in the order indicated by a pixel block of 16-pixel square shown in Fig. 14.

The feature of the present embodiment is to be
20 able to easily generate the address signal representing the above reading order by converting the bit positions of the signal from the counter 90112.

Concretely, the bit exchange is controlled by the bit exchanger 90111 according to a list shown in Fig.
25 15. Thus, the address of the corresponding order is output to the address bus 9014, the pixel data is read from the memory 9012 in the desired order, and the read

data is transferred to the image bus 9013 through the image bus I/F 90113.

In Fig. 15, symbol $C(i)$ denotes i-th bit of the output signal from the counter 90112 (i.e., the input 5 signal to the bit exchanger 90111), and symbol $A(i)$ denotes i-th bit of the output signal from the bit exchanger 90111 (i.e., the input signal to the counter 90112). A representation " $A(i) \leftarrow C(i)$ " indicates that the input signal $C(i)$ is selected and output as the 10 output signal $A(i)$, and a representation " $A(i) \leftarrow \text{not } C(i)$ " indicates that the signal obtained by bit-reversing the input signal $C(i)$ is selected and output as the output signal $A(i)$.

Next, an operation example of the bit exchanger 15 90111 will be explained. Fig. 16 shows the bit exchange contents in the bit exchanger 90111 to achieve the address generation in the above order for performing the image rotation process of 90° counterclockwise. In Fig. 16, the values in the right 20 column are the output values of the bit exchanger 90111 corresponding to the respective counter values in the left column. As described above, the counter 90112 outputs the ascending-order binary numbers increased one by one in synchronism with the clock, and the 25 obtained value is input to the bit exchanger 90111. Then, the bit exchanger 90111 exchanges each bit of the input value according to the predetermined bit exchange

content, and outputs the exchanged bit. In case of performing the image rotation process of 90° counterclockwise, as described above, in the bit exchange contents, the upper four bits of the input 5 eight-bit value are bit-reversed and set to the lower four bits of the output value, and the lower four bits of the input eight-bit value are bit-reversed and set to the upper four bits of the output value. By such the bit exchange, as shown in Fig. 16, the value "15" 10 (i.e., the binary "00001111") is output for the counter value "0" (i.e., the binary "00000000") from the bit exchanger 90111, the value "31" (i.e., the binary "00011111") is output for the counter value "1" (i.e., the binary "00000001"), and the value "47" (i.e., the 15 binary "00101111") is output for the counter value "2" (i.e., the binary "00000010"). As a result, with respect to the ascending-order counter values counted up from "0" to "255" in synchronism with the clock, the desired address string of "15, "31", "47", "63", ..., 20 "224" and "240" synchronous with the clock is generated. Then, by sequentially reading the pixel data from the memory 9012 in synchronism with this address string, the image rotation of 90° counterclockwise can be performed.

25 Next, an internal structure of the bit exchanger 90111 will be explained. Fig. 17 is a diagram showing the bit exchanger 90111. In the bit exchanger 90111,

the eight-bit value input from the counter 90112 is further input to eight bit exchange units respectively. The eight bit exchange units perform bit exchange processes respectively corresponding to eight kinds of
5 image conversion processes such as the image rotation of 90° counterclockwise, the image rotation of 180° counterclockwise, the image rotation of 270° counterclockwise, the image reversal (not shown), the image rotation of 90° counterclockwise after the image
10 reversal (not shown), the image rotation of 180° counterclockwise after the image reversal (not shown), the image rotation of 270° counterclockwise after the image reversal (not shown), and the through process.
It should be noted that the not-shown bit exchange unit
15 can be easily designed on the basis of the bit exchange contents of Fig. 15. The output from each bit exchange unit is input to the selector. Then, the output signal of the bit exchange unit achieving the desired image rotation and reversal process is selected and output as
20 the address input signal of the memory 9012, in response to the control signal from the rotation/reversal mode memory 90110.

The above rotation/reversal process was explained for one block of 16×16 pixels. However, if the above
25 process is performed to all of the plural blocks, the rotation/reversal process of the entire image can be performed. Such an operation will be explained in

detail in the second embodiment.

As described above, in the system that the two-dimensional image is represented by the aggregate of the pixel data and all the pixel data are one-dimensionally arranged and transferred in synchronism with the clock signal, the image processing apparatus according to the first embodiment includes the counter 90112 for sequentially generating and outputting regular binary numerical signals in synchronism with a clock signal, the bit exchanger 90111 for generating and outputting, from the output signal by the counter 90112 being managed as the input signal, the signal that order of bits in the input signal has been exchanged or the signal that the bits in the input signal have been reversed, and the memory 9012 that the reading/writing can be performed for only the area designated under the control of the address input signal being the output signal from the bit exchanger 90111. Thus, since the image rotation/reversal process can be achieved by combining the general-purpose counter 90112, the general-purpose memory 9012 and the simple bit exchanger 90111 and operating such the combination, the circuit size can be minimized as much as possible. Further, since the general-purpose circuits and the simple circuits are combined, an operation clock frequency of the apparatus can be easily increased as a whole to achieve the high-speed

operation. Further, since the simple structure that it is unnecessary to modify or change the circuits in the parts other than the memory even if the number of bits representing the pixel being the minimum unit of the 5 image increases is adopted, circuit's extendibility and diversion are excellent.

In the first embodiment, it was explained the example that the pixel data are stored in the memory 9012 according to the addresses of the predetermined 10 order, and the addresses exchanged by the bit exchanger 90111 are used as the reading addresses from the memory 9012, whereby the image rotation or the image reversal is performed. Conversely, even if the pixel data are stored in the memory 9012 according to the addresses 15 exchanged by the bit exchanger 90111 and the addresses of the predetermined order are used as the reading addresses from the memory 9012, the image rotation or the image reversal can be also performed.

(Second Embodiment)

20 In the first embodiment, the rotation or the reversal of the one-block image was explained in detail. In the second embodiment, it will be explained in detail a case where, when an image of one screen including plural blocks is rotated or reversed, 25 positional information before and after the rotation or the reversal of each of the plural blocks is considered.

In the present embodiment, the positional information for the entire image added to the block image before the process is converted into the positional information for the entire image after the process, and the converted positional information is added to the data of the rotated or reversed block and then output. The data to which the positional information was added is once stored in the image memory unit 8.

On the basis of the positional information after the conversion, the block images are sequentially output from the image memory unit 8. Thus, for example, the printer which is the output destination can output the image which is obtained by entirely rotating or reversing the former image.

In the second embodiment, the structure of the image processing apparatus is the same as that of the image processing apparatus in the first embodiment shown in Figs. 1 to 5, whereby explanation of the parts corresponding to those in the first embodiment will be omitted.

In the second embodiment, as well as the first embodiment, the two-dimensional image is represented by the aggregate of the pixel data, all the pixel data are one-dimensionally arranged, and the pixel data are then transferred in synchronism with the clock signal.

It should be noted that, in the drawings necessary

for the explanation of the second embodiment, the same components as those in the first embodiment are respectively denoted by the same numerals, and explanations thereof are omitted.

5 Fig. 18 is a block diagram showing the internal structure of the image rotation/reversal processing unit 9011 of Fig. 5. In Fig. 18, numeral 90110 denotes the rotation/reversal mode memory, numeral 90111 denotes the bit exchanger, numeral 90112 denotes the counter, numeral 90113 denotes the image bus I/F, and numeral 90120 denotes a block positional information conversion unit.

10

In Fig. 18, the data flow of the former image to the image rotation/reversal processing unit 9011 is as follows. In the image data and the positional information added to the image data which are input from the image bus 9013 to the image rotation/reversal processing unit 9011, the image data is transferred to the data bus 9015 through the image bus I/F 90113. The 15 block positional information input from the image bus 9013 to the image rotation/reversal processing unit 9011 is transferred to the block positional information conversion unit 90120 through the image bus I/F 90113.

20

Next, the image data flow after the image 25 rotation/reversal process is as follows. The image data which is read and input from the memory 9012 to the image rotation/reversal processing unit 9011

through the data bus 9015 is transferred to the image bus 9013 through the image bus I/F 90113. Further, the block positional information which is output from the block positional information conversion unit 90120 is
5 added to the image data, and then transferred to the image bus 9013 through the image bus I/F 90113.

Next, the operation in the image rotation/reversal process is as follows.

The output from the counter 90112 outputting the
10 ascending-order binary numbers is further output to the address bus 9014 through the bit exchanger 90111, so as to control the writing and reading addresses in the memory 9012. The bit exchanger 90111 is the bit arrangement changer which changes the order of input
15 bit data and outputs the data in the changed order. The bit exchanger 90111 which has the function to rearrange the input bit data for each bit and the function to perform bit reversal of the value of each bit data is controlled by the rotation/reversal mode
20 memory 90110. The rotation/reversal mode memory 90110 consists of the register of which the contents can be rewritten and read by the CPU 903, and acts as the part to determine the operation of the image rotation/reversal processing unit 9011.
25 The block positional information conversion unit 90120 which is controlled by the rotation/reversal mode memory 90110 performs the conversion to the block

positional information transferred through the image bus I/F 90113, and then transfers the converted block positional information to the image bus 9013 through the image bus I/F 90113.

5 As well as the first embodiment, Fig. 7 schematically shows one block. In the present embodiment, the image area of 16 pixels in the horizontal direction and 16 pixels in the vertical direction is handled as one block. Each of the small
10 squares shown in Fig. 7 corresponds to each of the pixels constituting one block, and the uniquely determined pixel number is added to each of the pixels. When the block image is transferred through the image bus 9013, the pixels are sequentially transferred in
15 the order of smaller pixel number. The details of the transfer through the image bus 9013 will be described later.

Fig. 19 is a diagram showing a case where the image is divided into the plural blocks and managed.

20 Hereinafter, a method of dividing the image data into the blocks and managing the divided blocks will be explained.

Under the control of the CPU 903, the image data stored in the image memory unit 8 is divided into the
25 blocks each of which is a 16-pixel square, and the process is performed to each block. Since each block is managed based on a set of uniquely determined

numbers (X, Y) by the CPU 903, the set of numbers acts as the positional information of this block in the image. Here, symbol X denotes the block number from the left along the horizontal direction based on zero origin representation, and symbol Y denotes the block number from the top along the vertical direction based on zero origin representation. Fig. 19 shows the block division diagram on which the positional information of each block is represented in the case where the image is divided into the plural blocks according to the above management method.

In the example shown in Fig. 19, an image is divided into ten blocks (i.e., 160 blocks) in the horizontal direction and eight blocks (i.e., 128 pixels) in the vertical direction. In this case, the number of blocks in the horizontal direction is "10", and the number of blocks in the vertical direction is "8".

When the image output by a print operation, a fax transmission operation or the like is performed, the image block stored in the image memory unit 8 is read one by one and output to the image output destination under the control of the CPU 903. At this time, the block of the positional information (0, 0) is first read and output without fail, and thereafter the blocks are read and output in the order of positional information number (1, 0), (2, 0), ..., (9, 7).

Therefore, if the image output operation such as the print operation or the like is performed after the positional information of each block is rewritten and thus the order of blocks is changed, the blocks stored
5 at the arbitrary positions in the memory can be sequentially output in the desired order. Namely, by previously rewriting the positional information of the respective blocks to become the positional information after the rotation/reversal process, it is possible by
10 the printer, the fax apparatus or the like to sequentially output the block images in the order from which the image rotation/reversal process is performed. Thus, by performing the two kinds of processes (i.e., the process to rewrite the positional information of
15 each block and the process to rotate or reverse the image in each block) for all the blocks within a page, the image rotation/reversal process for the entire page image can be achieved.

Figs. 20A to 20E show signal waveforms in the case
20 where the block data is transferred through the image bus 9013. The image is transferred by each block, in synchronism with an image bus transfer clock. The positional information of the block is added to the head of its block data.

25 In Figs. 20A to 20E, image data denoted by symbols "A" and "B" are the positional information.

Hereinafter, an image bus transfer procedure will

be explained in accordance with an execution procedure of the image rotation/reversal process.

First, the former block data to which the image rotation/reversal process is to be performed is input
5 to the image bus I/F 90113 through the image bus 9013. After the transfer of all the pixel data in one block ended, the block data which was subjected to the image rotation/reversal process is output to the image bus 9013 through the image bus I/F 90113.

10 In such the input step, an image bus transfer start signal is first sent from the image bus 9013 to the image bus I/F 90113, and at the same time the block positional information used as the image bus data and the pixel data constituting the block are sequentially transferred.
15

In the output step, a transfer request signal and an image bus transfer request signal are output from the image bus I/F 90113 to the image bus 9013. Since the image bus which received these request signals outputs an image bus transfer permission signal, the image bus I/F 90113 which received the permission signal continuously outputs and transfers the image bus transfer start signal, the block positional information, and the pixel data constituting the block.
20

25 The image bus data of Fig. 20A represents the former positional information of the block, and the image bus data of Fig. 20B represents the positional

information after the image rotation/reversal process of the block. In the drawings, numerals "0" to "255" denote the pixel data respectively.

The output pixel arrangement in Figs. 20A and 20C
5 is the arrangement in the case where the image rotation process of 90° counterclockwise is performed. Such the arrangement and other image rotation/reversal processes will be described later.

Hereinafter, the procedures of performing the
10 image rotation process and the image reversal process in the data processing unit 901 will be explained.

When the image rotation/reversal process is performed, the CPU 903 causes all the blocks to be subjected to the image rotation/reversal process in the
15 order of block positional information or consecutively. In this case, since the image rotation/reversal process is performed by each block, the process of each block is independently performed.

As well as the first embodiment, the procedure of
20 the image rotation/reversal process for one block will be explained.

The CPU 903 sends the positional information of the block to be processed to the I/F 900 so as to request the block data creation. Then, the I/F 900
25 reads the pixel data corresponding to the block positional information from the image memory unit 8, creates the block data based on the read pixel data and

the corresponding positional information, and transfers the created block data to the image rotation/reversal processing unit 9011. The waveshape of the image bus signal at this time is shown in the former part of
5 Figs. 20A to 20E.

The block positional information input to the image rotation/reversal processing unit 9011 is then transferred to the block positional information conversion unit 90120 through the image bus I/F 90113.
10 The block image data input in the image rotation/reversal processing unit 9011 is stored in the memory 9012 through the image bus I/F 90113. Here, as the memory 9012, a general-purpose memory which is controlled by the address bus 9014 and the data bus
15 9015 is used.

After the image data of one block (i.e., 256 pixels) was received, the image rotation/reversal processing unit 9011 starts to read the image data for each pixel from the memory 9012. Here, by the control
20 of the address bus 9014 to the memory 9012, the order of reading the pixel data is made different from the order of writing the pixel data. The image rotation/reversal process is achieved by such the control. For example, if the pixel data is read in the
25 order completely opposite to the order of writing the data, the image rotated by 180° can be obtained. Further, if the pixel data is read in the order

completely same as the order of writing the data, the image rotated by 0° (i.e., not subjected to the image rotation/reversal process) can be obtained. The details of such operations will be described later.

5 The read image data is transferred to the I/F 900 through the image bus 9015 subsequent to new block positional information converted by the block positional information conversion unit 90120. The waveshape of the image bus signal at this time is shown
10 in the latter part of Figs. 20A to 20E.

The I/F 900 interprets the positional information of the block, and writes the block pixel data in the corresponding image memory area.

15 Next, how to access the memory 9012 achieving the image rotation/reversal process will be explained in detail.

The image rotation/reversal processing unit 9011 has the two operation steps, i.e., the image data input step and the image data output step.

20 In the image data input step, as described above, the image data for each pixel is input to the image rotation/reversal processing unit 9011 through the image bus 9013. Further, in the image data output step, as described above, the image data is output from the image rotation/reversal processing unit 9011 through the image bus 9013.

These two operation steps will be explained

hereinafter with reference to Fig. 18 being the block diagram showing the structure of the image rotation/reversal processing unit 9011.

In the image data input step, the image
5 rotation/reversal processing unit 9011 writes the pixel data sequentially input in the order shown in Fig. 7 in the memory 9012. At this time, the address of the pixel number shown in Fig. 7 is used as the writing address such that the writing address becomes unique
10 with respect to each pixel data. Concretely, the bit exchange in the bit exchanger 90111 is set to be through, and the output completely same as the output of the counter 90112 is transferred to the address bus 9014, whereby the pixel data is written in the memory
15 9012. After the transfer of all the pixel data ended and the writing of all the pixel data in the memory 9012 ended, the operation step of the image rotation/reversal processing unit 9011 is changed to the image data output step.

20 In the image data output step, the image rotation/reversal processing unit 9011 sequentially reads the image data from the memory 9012, and transfers the read data for each pixel through the image bus 9013. In this case, the reading order of the
25 data from the memory 9012 and the transferring order of the data to the image bus 9013 are controlled as follows according to a kind of rotation process

performed to the image data and whether or not the reversal process is performed.

When the image rotation process of 90° counterclockwise is performed, the data is read and transferred in the order indicated by the pixel block of 16-pixel square shown in Fig. 8, i.e., the order of "15", "31", "47", "63", "79", "95", "111", "127", "143", "159", "175", "191", "207", "223", "239", "255", "14", "30", "46", ..., "208", "224" and "240".

Similarly, when the image rotation process of 180° counterclockwise is performed, the data is read and transferred in the order indicated by the pixel block of 16-pixel square shown in Fig. 9. When the image rotation process of 270° counterclockwise is performed, the data is read in the order indicated by the pixel block of 16-pixel square shown in Fig. 10. Further, when the image reversal process is performed, the data is read in the order indicated by the pixel block of 16-pixel square shown in Fig. 11. Further, when the image rotation process of 90° counterclockwise is performed after the image reversal process was performed, the data is read in the order indicated by the pixel block of 16-pixel square shown in Fig. 12. Similarly, when the image rotation process of 180° counterclockwise is performed after the image reversal process was performed, the data is read in the order indicated by the pixel block of 16-pixel square shown

in Fig. 13. When the image rotation process of 270° counterclockwise is performed after the image reversal process was performed, the data is read in the order indicated by the pixel block of 16-pixel square shown
5 in Fig. 14. Concretely, the bit exchange is controlled by the bit exchanger 90111 according to the list shown in Fig. 15. Thus, the address of the corresponding order is output to the address bus 9014, the pixel data is read from the memory 9012 in the desired order, and
10 the read data is transferred to the image bus 9013 through the image bus I/F 90113.

Since Fig. 15 was explained in the first embodiment, further explanation here is omitted. Further, since the structure of the bit exchanger 90111
15 was already described with reference to Fig. 17, further explanation here is omitted.

Next, a conversion procedure of the block positional information will be explained in detail.

The former block positional information transferred from the image bus 9013 at the first of the image data input step is transferred to the block positional information conversion unit 90120 through
20 the image bus I/F 90113. Then, while the block image data from the image bus 9013 at the remainder of the image data input step is being written in the memory
25 9012 through the image bus I/F 90113, the block positional information conversion unit 90120 creates

new block positional information. Then, at the first of the image data output step, it is set to be able to transfer the new block positional information to the image bus 9013 through the image bus I/F 90113. It
5 should be noted that the conversion of the block positional information performs the control corresponding to the kind of image rotation/reversal process.

Fig. 21 shows a block position information
10 conversion method list for types of image rotation/reversal processes. Such the conversion method can be performing by adders and bit reversal circuits as shown in Fig. 21, the block positional information conversion unit 90120 can be easily
15 achieved by using the selector circuit operating in correspondence with the image rotation/reversal process.

Further, two kinds of numerals necessary in the conversion methods (i.e., the number of blocks in the
20 horizontal direction and the number of blocks in the vertical direction, these blocks constituting the entire image) are previously written in a register of the image rotation/reversal processing unit 9011 and used in the conversion process under the control of the
25 CPU 903. The number of blocks represents the number of blocks in each of the horizontal and vertical directions constituting the former image before the

image rotation/reversal process is performed. For example, in the former image shown in Fig. 19, the number of blocks in the horizontal direction is "10", and the number of blocks in the vertical direction "8".

5 Fig. 22 is a diagram showing the case where the images divided into 10 blocks in the horizontal direction and eight blocks in the vertical direction shown in Fig. 19 are rotated counterclockwise by 90° . Namely, Fig. 22 shows the result which is obtained by
10 converting the positional information (X, Y) of each block.

For example, it can be understood in Fig. 22 that, by the image rotation process of 90° counterclockwise, the positional information (0, 0) of the upper left
15 block is converted into the positional information (0, 9), and similarly the positional information (1, 0) of its adjacent block is converted into the positional information (0, 8).

Next, the conversion of the positional information
20 will be explained in detail.

In the transformations of Fig. 21, symbol X denotes a horizontal-direction number of the positional information of each block in the former image, symbol Y denotes a vertical-direction number of the positional
25 information of each block in the former image, symbol X' denotes a horizontal-direction number of the positional information of each block in the rotated or

reversed image, and symbol Y' denotes a vertical-direction number of the positional information of each block in the rotated or reversed image. It should be noted that the horizontal-direction number X and the 5 vertical-direction number Y respectively correspond to the positional information (X, Y) of each block shown in Fig. 19, and the number is an integer starting from "0". Further, symbol XX denotes the number of total blocks of the former image in the horizontal direction, 10 and symbol YY denotes the number of total blocks of the former image in the vertical direction. In the example shown in Fig. 19, the number XX is "10", and the number YY is "8".

The transformations in Fig. 21 are represented by 15 formulae. In each formula, the result of calculating the value at the right side of the arrow (\leftarrow) is given as the value at the left side. Namely, for example, in case of the image rotation process of 90° counterclockwise, since $X' \leftarrow Y$ and $Y' \leftarrow XX-1-X$, it is 20 represented that the block positional information is ($Y, XX-1-X$) after the block of which the block positional information is (X, Y) was rotated counterclockwise by 90° . Concretely, for example, if the image of Fig. 19 is rotated counterclockwise by 25 90° , the positional information (0, 10-1-0) is obtained by substituting the positional information (0, 0) of the upper left block for the transformation, this

transformation is calculated, and thus the block after the rotation has the positional information (0, 9). Further, with respect to the adjacent block, the positional information (0, 10-1-1) is obtained by 5 substituting the positional information (1, 0) of this block for the transformation, and thus the block after the rotation has the positional information (0, 8).

In Fig. 21, the circuit structure is expressed in graphical symbols and their connection lines. Namely, 10 in this circuit structure, the signals X, Y, XX and YY input from the left are signal-processed to generate the signals X' and Y' output to the right. The graphic symbols in Fig. 21 are symbols which are generally used and indicate a buffer, an inverter (i.e., a bit reversal circuit), and an adder. It should be noted 15 that, in this case, the buffer is an eight-bit input/eight-bit output buffer which directly outputs the input signal as it is, the inverter is an eight-bit input/eight-bit output inverter which inverts each bit of the input signal and outputs the obtained signal, and the adder is an eight-bit two-way input/eight-bit 20 output adder which adds together the input two-way signals as positive numbers, throws away the carry information exceeding the eight bits, and outputs only 25 the eight-bit information. Namely, for example, in case of the image rotation of 90° counterclockwise, the signal Y is directly output as the signal X', and the

signal obtained by adding together the signal bit-inverted from the signal X and the signal XX is output as the signal Y'. Concretely, for example, in the case where the image of Fig. 19 is rotated counterclockwise
5 by 90°, the positional information ($X, Y = (0, 0)$) of the upper left block, the number of total blocks in the horizontal direction ($XX = 10$), and the number of total blocks in the vertical direction ($YY = 8$) are input to the circuit configuration, and the positional
10 information (X', Y') after the rotation process is obtained as the output signal. Here, since $Y = 0$, the eight-bit signal Y is represented as "00000000" in binary. Since $X = 0$, the eight-bit signal X is represented as "00000000" in binary. Since $XX = 10$,
15 the eight-bit signal XX is represented as "00001010" in binary. Since $YY = 8$, the eight-bit signal YY is represented as "00001000" in binary. Therefore, as the signal X', the signal of "00000000" which is the same as the signal Y is output. As the signal Y', the
20 signal of lower eight bits "00001001" of the result "100001001" obtained by adding together the signal "11111111" obtained by inverting each signal of the signal X and the signal XX is output. Namely, the positional information (0, 0) is converted into the
25 positional information (0, 9) by this circuit.

The conversion of the positional information in other rotation and reversal can be easily performed by

the circuits shown in Fig. 21.

Then, by selecting one of the plural circuits in accordance with the selected rotation/reversal process, the positional information can be easily converted.

5 As described above, in the image processing apparatus according to the second embodiment, the two-dimensional image is represented by the aggregate of the pixel data, all the pixel data are one-dimensionally arranged, and the pixel data are then transferred in synchronism with the clock signal. In such a system called an image separation system, the aggregate of the pixel data of $m \times n$ size (m, n are natural numbers) obtained by dividing the pixel data constituting the image is handled as the block, the 10 image is divided into the plural blocks to be handled, and the block positional information representing the position where the corresponding block is set in the entire image is added to this block together with the pixel data. The image rotation/reversal processing 15 unit 9011 for performing the image rotation/reversal process to the input block image and outputting the processed block image, and the block positional information conversion unit 90120 for converting the block positional information of the input block image 20 and outputting the converted information are provided. The conversion process by the block positional 25 information conversion unit 90120 corresponds to the

image rotation/reversal process by the image rotation/reversal processing unit 9011. Then, the positional information representing the position where the block image should stand in the entire image after 5 the image rotation/reversal process is output

Thus, according to the image processing apparatus of the second embodiment, the block image is subjected to the image rotation/reversal process, and at the same time the positional information of the corresponding 10 block is changed in the entire image. Thus, it is possible to omit a redundant procedure that the block image is once stored in the memory 9012 and then read again and rewritten at the correct position, whereby a processing time necessary in the image 15 rotation/reversal process can be shortened. Also, parallel operations can be achieved. Namely, since the process for each block can be independently performed, even if there are image rotation/reversal requests to the plural images, such the requested processes can be 20 simultaneously started and performed for each block in parallel. Further, by adopting the structure that the plural image rotation/reversal processing units are disposed, it is possible to end the processes for all the blocks in short time by performing the plural block 25 processes in parallel, thereby having expansion for high-speed image rotation/reversal process.

In addition to the above first and second

embodiments, the object of the present invention is applicable to a case where the storage medium recording program codes of software to realize the functions of the above embodiments is supplied to a system or 5 apparatus, and then a computer (or CPU or MPU) in this system or apparatus reads and executes the stored program codes.

In this case, the program codes themselves read from the storage medium execute the functions of the 10 above embodiments, whereby the storage medium storing these program codes constitutes the present invention.

As the storage medium from which the program codes are supplied, e.g., a floppy disk, a hard disk, an optical disk, a magneto-optical disk, a CD-ROM, a CD-R, 15 a magnetic tape, a nonvolatile memory card, a ROM, or the like can be used.

Further, it is needless to say that the present invention includes not only the case where the functions of the above embodiments are executed by the 20 program codes read by the computer, but also a case where an OS (operating system) or the like running on the computer executes a part or all of the actual processes based on instructions of the program codes and thus the functions of the above embodiment are 25 executed by such the processes.

Further, it is needless to say that the present invention includes a case where the program codes read

from the storage medium are once written in a memory provided in a function expansion board inserted in the computer or a function expansion unit connected to the computer, and then a CPU or the like provided in the 5 function expansion board or the function expansion unit performs all or a part of the actual processes based on instructions of the program codes, whereby the functions of the above embodiments are achieved by such the processes.

10 As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the present invention is not limited to the specific embodiments thereof except as defined in 15 the appended claims.